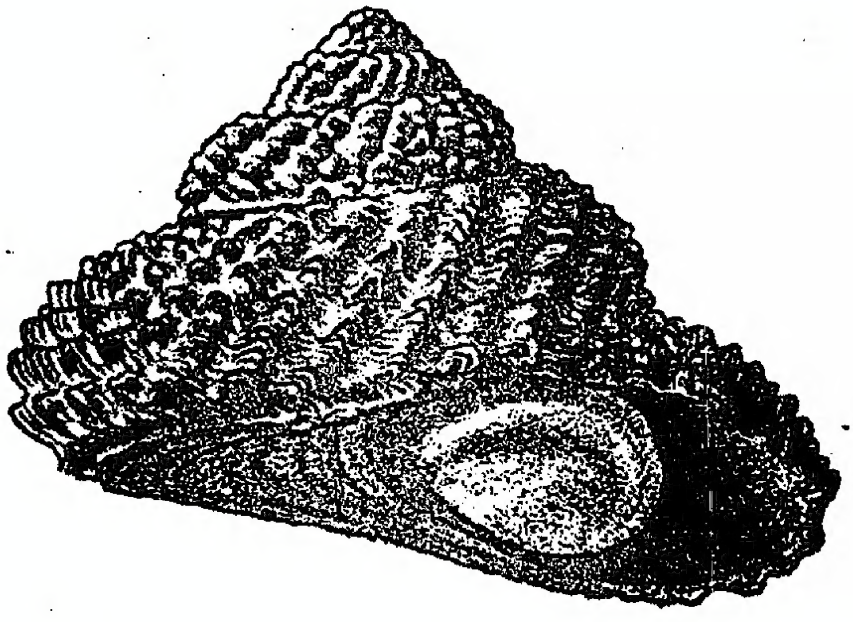
COOKIA



Journal of the Wellington Shell Club

New Zealand

VOL 1 NO 3

As we conclude Volume 1 of "Cookia" I would like to thank all those members, who by contributing papers of such a high standard have ensured the success of this publication.

The first part of Volume 2 is due on May 1st but this will only be possible if contributions are received by April 1st. Articles (preferably typed) should be sent to the address below.

Concurrent with the next issue will be an index for Volume 1.

EDITOR

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The larger New Zealand Calliostomatinae

(Study group 24 June 1976)

Alan Beu

Calliostoma and its relqtives are a world-wide group of seaweed-grazing, colourful, conical trochids that are popular with collectors. Despite their abundance and popularity around New Zealand, many of the taxa are not well understood even now, and several writers (mainly Oliver, 1926; Finlay, a little later in 1926; Dell, 1950) have made an attempt to sort out the large range of variation, all with very different conclusions and all, it now appears, incorrectly to some extent. Many species have developed geographic subspecies or even clinal geographic variation that we still don't have enough material to understand fully, and several species (notable the C. pellucidum complex) have distinct ecological forms in deep and shallow water. So I'll have another attempt at straightening this complex out into something nearer to biological reality.

Family Trochidae

Genus Calliostoma Swainson, 1840

Type species: Trochus conulus Linnaeus, 1758

Mediterranean.

The type species usually cited is Trochus zizyphinus Linnaeus, by monotypy; but Swainson (1840, p. 351) included 8 species in Calliostoma (proposed on p. 218, but surely both "at the same time" within the meaning of the Code of Zoological Nomenclature) without designating a type species. Therefore the designation by Herrmannsen (1846, p. 154) of another of Swainson's included species, T. conulus Linn., must be accepted.

Synonyms (many non-New Zealand ones omitted):

Salispotens Iredale, 1924 (type: Trochus armillatus Wood, 1828 Australia); Maurea Oliver, 1926 (type: Trochus tigris Martyn, 1784); Mauriella Oliver, 1926 (type: Trochus punctulatus Martyn, 1784); Calliotropis Oliver, 1926 (non Seguenza, 1903) - Calotropis Thiele, 1929 (type: Trochus cunninghami "Gray"); Venustas Finlay, 1926 (type: Trochus tigris Martyn); Mucrinops Finlay, 1926 (type: Zizyphinus spectabilis A. Adams, 1855).

I can see no significant criteria that distinguish Mediterranean and American species placed in Calliostoma from New Zealand species placed in Maurea, Australian species placed in Salsipotens, or Japanese species placed in Tristicotrochus, and regard them all as synonyms, at least in the broad sense. I'm sure you'll agree that Calliostoma granulatum (Born) (type species of subgenus Ampullotrochus Monterosato, 1890) is particularly similar to New Zealand shells.

However, several subgenera of Calliostoma have been proposed for overseas species, and the fitting of Japanese, Australian and New Zealand species into these subgenera is a major task that needs access to many more animals of overseas species than are available here, as some of the subgenera are based on radular differences. Subgenera that need to be considered are Ampullotrochus Monterosato; Zizyphinus Gray, 1843; Tristicotrochus Ikebe, 1942 (Knight, Batten & Yochelson 1960, p. 1257-8); Kombologion Clench and Turner, 1960, p. 37 (type: Calliostoma bairdii Verrill and Smith, 1880); and Elmerlinia Clench and Turner, 1960, p. 29 (type: Trochus jujubinus Gmelin, 1791).

The subgenus Kombologion, containing species with broader 1st lateral radular teeth than in Calliostoma (s. str.), includes shells with keeled basal angles, beaded spiral cords, and straight side profiles, as well as some with more rounded bases, and seems likely to be the subgenus New Zealand species belong in. However, it also seems likely that both Ampullotrochus and Tristichotrochus are earlier names for Kombologion.

Some Carribbean and South American species not placed in subgenera by Clench and Turner (1960) resemble New Zealand species of Calliostoma (e.g., C. sarcodum (Dall, 1927), Caribbean, resembles C.punctulatum; C. carcellesi Clench and Aguayo, 1940, Argentina, is extremely similar to C. spectabile foveauxanum and could be merely another geographic subspecies in the C. spectabile complex) so if Maurea turns out to be a useful subgenus, some species outside New Zealand probably belong in it, too.

In the present confused state of subgenera of Calliostoma, I propose to include all New Zealand species in Calliostoma (sensu lato).

New Zealand species

Calliostoma megaloprepes (Tomlin, 1948)

- a rather low-spired species with rounded whorls and rounded base, a distinct, narrow shoulder below the suture, a pale brownish pink to pinkish brown colouration, shining surface, and few, widely spaced, spiral cords that are mostly smooth but bear beads near the upper suture and near the columella. Occurs only on the narrow continental shelf around Macquarie I.

Calliostoma pellucidum (Valenciennes, 1846)

- a moderately tall-spired species with rounded whorl profile, rounded basal angle, and rows of evenly spaced, small, coarse beads over the whole surface, as coarse and brightly sculptured on the base as on the whorl sides; with prominent pattern of bright red-brown colour splashes near the upper sutures and around the basal angle. A few specimens from northern North Island have a flat whorl profile and a weakly developed (but obvious) keel around the basal angle (forma spirata Oliver, 1926) but seem to be merely a poorly understood variant in northern populations. Two large, magnificent shells from Three Kings in National Museum may be forma spirata, a weird form of waikanae (see below) or a new species. Found throughout mainland New Zealand from Spirits Bay to Stewart Island but not reported from the Chatham Islands; dredged alive with live C. waikanae north of Kapiti Island.

Calliostoma punctulatum (Martyn, 1784)

Several forms of this species have been named, based on variation of the spire angle, whorl inflation, or coarseness of the granular sculpture, but all named forms (but one) intergrade. One geographic subspecies is recognised.

C. punctulatum punctulatum (Martyn)

- the common coarsely sculpured, round whorled, dark brown shell found throughout mainland New Zealand and Stewart Island. The rows of coarse beads are so closely spaced that the surface is covered with evenly spaced, closely packed beads. Shells with coarse nodules have been regarded as the typical form, and those with finer nodules as the "subspecies" stewartiana Oliver, 1926 (- urbanior Finlay, 1926) but both sculptural variants occur throughout New Zealand. Large shells with inflated whorls have been called forma ampla (Powell, 1939) but intergrade

completely with other forms and occur occasionally in all populations. Some shells from north-eastern North Island have an unusually narrow spire angle and tall, straight-profiled spires and have been called the "species" osbornei (Powell, 1926) but almost none of these maintain their narrow spire angle until adulthood and some specimens seen from the East Coast change from osbornei at the top of the spire to punctulatum at full size, showing that osbornei is merely a narrow-spired subtidal form of punctulatum. The "subspecies" multigemmatum (Powell, 1952) was based on large, thin-shelled, consistently very finely sculptured specimens trawled from the outer continental shelf of Otago and South Canterbury, but Portobello Marine Biological Station collections show that the common form on the shelf in this area is markedly smaller than typical multigemmatum, and identical to the stewartianum form of punctulatum. Thus the multigemmatum form, also, intergrades with punctulatum and is regarded as a synonym.

C. punctulatum benthicolum (Dell, 1950)

- a consistent form with the shape and size of typical punctulatum and beads of about the same size as in forma stewartianum, but with cream spiral interspaces between the rows of beads (as if each alternate row of typical punctulatum beads was left off) and with the bead rows coloured dark brown both between and on beads, so that the shell is banded brown and cream. Found only in shallow water (less than about 150 m) on Mernoo Bank (Canterbury end of Chatham Rise).

Calliostoma selectum (Dillwyn, 1817)
- the name cunninghami was first provided for this species by Griffiths and Pidgeon in 1833. Cernohorsky (1974, p. 149, fig. 7)) illustrated one of the type specimens of C. selectum (Dillwyn, 1817) in the University Zoological Museum, Copenhagen, and showed that this earlier name must be used for the common New Zealand sand beach species.

This low-spired, flat-sided, finely sculptured, fawn species with a relatively sharp basal angle is common throughout New Zealand on shallow sand substrates off ocean beaches. Some specimens from the deeper part of the depth range (about 60-80 m) are very large and have slightly taller spires than specimens from shallower water, and Oliver (1926) originally regarded this form as an Otago subspecies of selectum when he named it pagoda. However, both forms occur throughout New Zealand, and intergrade, so there can be no doubt that pagoda is part of the variation of selectum.

Calliostoma spectabile(A. Adams, 1855)

This tall-spired, coarsely sculptured species occurs in two geographic sub-species.

C. spectabile spectabile (A. Adams)

- the form at the Auckland and Campbell Islands is thicker shelled, lower spired, more coarsely sculptured and more darkly coloured than are specimens from mainland New Zealand. The sculpture is the coarsest of New Zealand species, and the colour is dark red-brown. Dredged in shallow water around Auckland and Campbell Islands, and commonly washed ashore at Auckland I.

C. spectabile foveauxanum (Dell, 1950)

- differs from C. spectabile spectabile in its larger maximum size, taller spire (at least in large Foveaux Strait specimens), much finer and more closely spaced surface beads, and pale fawn colour. Specimens from the northern part of the geographic range, off South Canterbury to Otago Peninsula, mostly have lower

spires and more rounded whorl profiles than specimens from further south, and were named the "species" blacki (Powell, 20 Dec. 1950) whereas most shells from off South Otago and Stewart Island have tall spires and almost straight sides (typical foveauxanum Dell, 1 Feb. 1950). However, both forms occur together throughout the two areas, and there is a nice intergrading population from North Otago in the National Museum, and it is clear that blacki is based on small, low-spired specimens of C. spectabile foveauxanum.

Calliostoma tigris (Gmelin, 1791)

- this is the largest and most spectacular member of the genus in New Zealand (and probably in the world), with inflated, rounded whorl profiles and base, a polished surface, very fine granular sculpture, and a colour pattern of cream to pale tan axial streaks on a bright reddish brown background. Again two geographic subspecies are recognised.

C. tigris tigris (Gmelin)

- the axial colour lines are narrow and clearly defined. Occurs on subtidal algae throughout mainland New Zealand; particularly large in the far north. Often common when found by SCUBA divers.

C. tigris chathamense (Dell, 1950)

- Chatham Islands specimens have only faint, diffuse colour lines. Common at Owenga.

Calliostoma turnerarum (Powell, 1964)

- the lowest-spired species known from New Zealand, similar to C. selectum but with markedly weaker sculpture, a streaked"dot-dash" colour pattern, and a more inflated whorl profile. About 300 to 500 m in the Bay of Plenty.

Calliostoma waikanae (Oliver, 1926)

- the relationships of and distinctions between the named subtidal forms previously regarded as "subspecies" of C. pellucidum are very obscure as yet. They were regarded as forms of pellucidum because their bright red-brown colour pattern is similar to that of C. pellucidum, but as they live alongside C. pellucidum almost throughout their geographic range they are here considered to be a distinct species. Typical C. waikanae from Waikanae Beach, west Wellington, and dredged alive with C. pellucidum in the Kapiti-Wanganui area, is a form with a very low spire, a polished shell surface, very faint, widely spaced rows of beads, a strongly keeled base that is markedly paler and more finely sculptured than the sides, and often a prominent thin, brown epidermis. Usually the colour pattern consists of markedly larger splashes than in C. pellucidum. Similar shells from Hauraki Gulf to Northland(C. "pellucidum" haurakiense Dell), the continental shelf off Otago and Southland (C. "pellucidum" forsterianum Dell), and Chatham Island (C. "pellucidum" moriorium Powell) have slightly taller spires and slightly coarser sculpture than on west Wellington specimens, but there can be little doubt that they belong in the same species. Understanding of the geographic forms must await study of much larger collections than are available at present.

Calliostoma n. sp.

A few specimens from the Antipodes Islands in the National Museum, and possibly a single specimen from 200 m off South Canterbury, belong in an unnamed species with strongly rounded whorls, a moderate spire height, and sculpture of strongly raised, widely spaced granular spiral ridges. The Canterbury shell is white,

whereas Antipodes Islands specimens are pinkish brown as in C. megaloprepes.

Genus Otukaia Ikebe, 1942

Type species: Calliostoma kiheiziebisu Otuka, deep water, off Japan.

Synonym: Alertalex Dell, 1956, Type species: Alertalex blacki Dell, 1956, New Zealand.

Otukaia blacki (Dell, 1956)

Dell (1956) originally proposed a genus Alertalex for this species, but later (Dell 1963, p. 208) he realized that it had been named previously in Japan.

Otukaia blacki is easily recognised by its tall spire, smooth shining surface, nacreous silvery white colour (live shells are almost transparent), strongly keeled basal angle, and three prominent, widely spaced, finely beaded spiral cords on the upper surfaces of the whorls. Taken uncommonly in deep water (300-800 m) all around New Zealand.

Otukaia n. sp.

Several specimens in New Zealand Oceanographic Institute from deep water off western Northland represent a second species of Otukaia, with a much lower spire, much less prominent sculpture and less polished surface than in O. blacki, and coloured pale pink.

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THE NEW ZEALAND SPECIES OF THE GENUS DELOS

B. Hazelwood
D. Roscoe

The land snails known as Delos are small (up to approx. 8 mm. across) and look like tiny, flat Paryphantas. They belong to the same family as Paryphanta, Powelliphanta, Rhytida, (Wainuia), Amborhytida, Delouagapia and Schizoglossa, as well as many overseas genera. All of these groups have the animals with long, sharp radular teeth, which indicates a carnivorous habit, the teeth being used to hook into live prey (usually smaller snails and worms), hauling them into the stomach for digestion.

Delos has been said to differ from the other above groups by being ovoviviparous (holding eggs internally until hatched, then producing live young), whereas the other groups are oviparous (laying eggs from which the young hatch). However, nobody seems to have seen which it actually lays (eggs or live young), so the point has not yet been proven.

In this article, we use Pilsbry's family name Rhytididae for all the above genera instead of the name Paryphantidae which has been used up to now. The last time Rhytididae was used for New Zealand shells was in Suter's (1913) Manual of the New Zealand Mollusca; this name has remained in use outside New Zealand, and is used by Dr Solem (the recognised authority for this group) in discussing Pacific Island and Australian species. Dr Climo has agreed to follow his lead, to create uniformity throughout the family's range.

LITERATURE

Since Suter's 1913 Manual, this attractive group has been rather neglected, as the only mentions (apart from occasional listing in checklists) appear to be as follows:

1952: A.W.B. Powell: Four New Species of New Zealand Land Snails and the Systematic Position of Gerontia cordelia Hutton. Rec. Auck. Inst. & Mus., Vol. 4 No. 3 pp 163-185.

1953: M. T. Te Punga: The Paryphantidae and a Cook Strait Land Bridge. N.Z.J.Sci. & Technol.,Sect.B, Vol. 35 No. 1, pp. 51-63 (ref. on p. 62).

1967: N. W. Gardner: Descriptions of six new species of Land Snails from the Far North of New Zealand. Trans. Roy. Soc. N.Z. Zool., Vol. 8 No. 21, pp. 215-220.

1973: F. M. Climo: The Systematics, Biology and Zoogeography of the Land Snail Fauna of Great Island, Three Kings Group, New Zealand. J.R.S. N.Z., Vol. 3 No. 4, pp.565-628.

1975: F. M. Climo: Biogeography and Ecology in New Zealand: The Land Snail Fauna. Junk, Amsterdam. pp.475-477 & Fig. 9.

Gardner's 1967 mention of Delos is as follows:

> "While Delos jeffreysiana (Pfeiffer) has been recorded by Suter in his Manual as occurring at Cape Reinga the actual specimens which are in the Suter collection were subsequently re-identified by Powell (1952 p. 167) as being Delouagapia cordelia (Hutton). Delos jeffreysiana does in fact occur not uncommonly from Cape Reinga through to Unuwhao, at times together with Delouagapia."

Te Punga's 1953 mention is also brief, and is worth quoting in full, as it summarised the situation as known then:

> "DELOS. The carnivorous, ovoviviparous genus Delos is represented in New Zealand by three species, D.(Delouagapia) cordelia (Hutton) (See Powell, 1952, p. 167), D.coresia (Gray, 1850), with shell diameter 4 mm., and D.jeffreysiana (Pfeiffer, 1853), with shell diameter 7 mm. D.(D) cordelia and D.jeffreysiana are not found south of Auckland province, and D.coresia is confined to the northern portion of the North Island except for a more southerly occurrence in the Forty Mile Bush (between the Manawatu River and Masterton) on the drier and warmer side of the Tararua Range (Suter, 1913, p. 789). The three species appear to be warmth-loving, and their absence south of latitude 41°S. may be dictated by temperature requirements, particularly for ovoviviparity."

Latitude 41°S. passes through the North Island just South of Masterton. In the more than twenty years since Te Punga's notes, more extensive collecting has shown that Delos jeffreysiana occurs from the Three Kings (above North Cape) through Northland down to Mt Messenger (Taranaki)-Taupo-Mamaku (Rotorua); and D.coresia occurs from the Far North, in most places in the North Island (usually in the foothills of mountain ranges), and also in the Marlborough Sounds area of the South Island (collected by Peter Cresswell). Delos coresia has been found at many localities below latitude 41°S.

SYSTEMATICS

ORDER: SIGMURETHRA

SUBORDER: HOLOPODA

FAMILY: RHYTIDIDAE

GENUS: Delos Hutton, 1904

(Genotype: Zonites (?) coresia Gray, 1850)

NAMED SPECIES:

Delos coresia (Gray, 1850)

Delos jeffreysiana (Pfeiffer, 1853)

Delos regia Climo, 1973

Delos striata Climo, 1973

Delouagapia Powell, 1952 would be better regarded as a full genus. It has affinities with the Pacific Islands Rhytidid genus Ouagapia and with Delos. The only named species is the one originally named Gerontia cordelia Hutton 1883. Norm Gardner of Auckland has found orange shells of what may be a second species of this genus in the Eastern part of the North Cape block; one of these shells is in the National Museum, Wellington.

TYPE DESCRIPTIONS

1. Delos coresia: Gray, J.E.: Description of a new genus and several new species of terrestrial, fluviatile and marine molluscous animals inhabiting New Zealand. P.Z.S., 1849 (1850), 166.

"Zonites ? coresia. Shell depressed, dark olive-green; with brown cross-bands covered with a thick, smooth, polished periostracum; spire scarcely raised, rather convex; whorls convex, last expanded, rounded on the edge and in front; axis broadly umbilicated, showing all the whorls; mouth roundish, sublunate; peristome thin, with the periostracum inflexed when dry. Diameter 1/6th of an inch. Habitat Auckland, New Zealand.

This shell is exactly like a very minute specimen of Helix busbyi. It differs from the former, Z.chiron, in being smaller, more depressed, and in the umbilicus being much wider, showing the front side of the upper whorls, which appear rather transverse."

Suter's description in his Manual (pp.787-788) is excellent, giving details also of the radula and the reproductive anatomy.

2. Delos jeffreysiana: The type description is given as M.H. Viv., iii, 1853, 105, but that in P.Z.S. 1852 (1854) p. 148 was probably intended to be the type description, being written earlier, Suter, on p. 789 of the Manual, gives an adequate description of the shell and radula.

3. Delos regia: Climo, three Kings Snails (cited earlier).

"Delos (Delos) regia n.sp..... Shell small (greatest diameter 4.2 mm.), relatively tightly coiled for a species of Delos, rib-striate, widely umbilicate. Sculpture consisting of numerous, low rounded, evenly spaced, radial rib-striae, interspaces smooth, spiral sculpture absent; whorls 4-4½, tightly coiled for a species of Delos; protoconch of 2 smooth whorls; colour uniformly yellowish-straw or radially streaked by irregularly spaced brown markings, the width of these varying considerably, protoconch transulent; umbilicus relatively wide, 1.7 mm. on 4.2 mm. specimen. Reproductive system similar to that of D.jeffreysiana described above, but the spermatheca is relatively stronger and has a constriction near the top thus almost allowing the recognition of a separate spermatheca and duct.

Radula with the formula 9 ± 0 ± 9, basal section of teeth curved upwards on inner edge, cusps low-profiled, thorn-like, recurved on inner edge but sweeping in a gentle sigmoid curve on outer edge.

Type material: Holotype (M 29 483) and 35 paratypes (M 29 476-29 482; 29 484) in National Museum, Wellington; 5 paratypes in Auckland Institute and Museum.

Type locality: Upper reaches, unnamed stream, near Tasman Stream, Great Island, in Kanuka Forest. F. M. Climo, 13/11/1970.

Distribution and remarks: On shell features and size this new species superficially resembles Delos coresia (Gray), figured here for comparison (Fig. 18, E-F) but differs in a number of respects. D.regia n. sp. has a regular radial sculpture, rib-striae, when present, on coresia are weakly and irregularly developed. D.regia has 4-4¼ whorls whereas D.coresia has 3-3¼, and as a consequence the shell of the latter has a relatively more greatly expanded body whorl. The protoconch of regia is composed of two whorls, while that of coresia is of only 1½ whorls. The umbilicus of regia is wider than that of coresia. D.regia is lacking in spiral sculpture while the shell of coresia is characteristically crinkled by discontinuous, wavy, spiral grooves.

Delos regia n.sp. was collected from the P.bollonsi arbutus colony, Tasman Valley, the unnamed stream near Tasman Stream and from Castaway Valley. It was most abundant under stones in remnant broadleaf groves in all except the type locality where it occurred in deep kanuka litter under logs of that tree. Being a smaller species than jeffreysiana, it can probably utilise the overall drier conditions of kanuka litter by retreating into smaller damp pockets which would be marginal for the water requirements of the twice as large jeffreysiana. Like jeffreysiana, regia occurs in two colour forms and the distribution of these is shown in table 4."

4. Delos Striata: Climo, Three Kings snails (cited earlier).

"Delos (Delos) striata n.sp.....Shell small (greatest diameter 4 mm.), more loosely coiled than regia n.sp., very strongly rib-striate, widely umbilicate, unicoloured. Sculpture consisting of numerous (80-90 on body whorl), very strong, rounded, radial rib-striae which crenulate the shell periphery, interspaces smooth and spiral sculpture lacking; whorls $3\frac{1}{2}$, rapidly expanding, body whorls intermediate in expansion between regia n.sp. and coresia; protoconch of $1\frac{3}{4}$ smooth whorls; colour uniformly yellow-straw, the occasional specimen

Showing very faint slightly darker radial smudges (2 on the undersurface of last quarter volution of holotype); shell very flattened, holotype of 4 mm. only 1.5 mm. in height; umbilicus very wide, 1.7 mm. on holotype, which was largest specimen collected. Reoroductive system similar to that of jeffreysiana; spermatheca of same shape but relatively larger; portion of penis above subterminal intersection of vas deferens, and below attachment of retractor muscle, longer in striata n.sp. than in jeffreysiana. Radula with the formula 9 ± 0 ± 9, basal section of teeth nearly straight, cusps thorn-like, recurved on inner edge but sweeping in a gentle sigmoid curve on outer edge. The very strong radial sculpture of striata n.sp. distinguishes it from all other New Zealand species of Delos.

Type material: Holotype (M 29 474) and 12 paratypes (M 29 475) in National Museum, Wellington; 5 paratypes in Auckland Instute and Museum.

Type locality: Placostylus bollonsi arbutus colony, in a remnant broadleaf grove. F. M. Climo 18/11/70.

Distribution and remarks: Delos striata has a limited distribution on Great Island, having been collected in only two localities, at the P.bollonsi arbutus colony and about 200 m below the Tecomanthe vine in Tasman Valley. In both these localities the species was living under stones covered in deep leaf litter under a canopy of broadleaf trees. D.striata occurred sympatrically with both jeffreysiana and regia at the arbutus locality and with the latter at the Tasman Valley locality. It was probably widespread at one time on Great Island, but the depredations on the vegetation by early Maori agricultural activities and later by goats restricted striata to the two rubble refugia mentioned above".

VARIETIES AND UNDESCRIBED SPECIES

One of us (Hazelwood) has just noticed that apart from the seven specimens collected at the P.bollonsi bollonsi colony, all the other specimens labelled "D.jeffreysiana" in the National Museum collection from the Three Kings are in

fact another species, not named, closely related to D.regia and S.striata, with a steeply shouldered wide umbilicus, tightly coiled whorls, and like D.jeffreysiana in size and appearance when seen from above. 15 shells from P.biarbutus colony; 1 shell 100m. below this colony; 2 from main valley, Southeast Bay landing slopes; 14 albino shells from top edge of Brachyglottis terrace below Castaway Valley Camp.

One of us (Roscoe), checking on this, noticed that the specimens from the P.bollonsi s.str.colony are also not jeffreysiana (which thus probably does not occur on the Three Kings Islands), but is yet another species, for all the world like a giant D.coresia. It has unusual deep grooves running over the edge of the shell, as in D.coresia but more pronounced, and the smaller umbilicus of the coresia etc. type, quite different from the cup-like excavated umbilicus of the three other Three Kings Deloses. Separated from D.coresia by the large size (6.8 mm.maj.diam. in the figured shell) and the grooves, and from D.jeffreysiana by the marked acceleration of the last whorl.

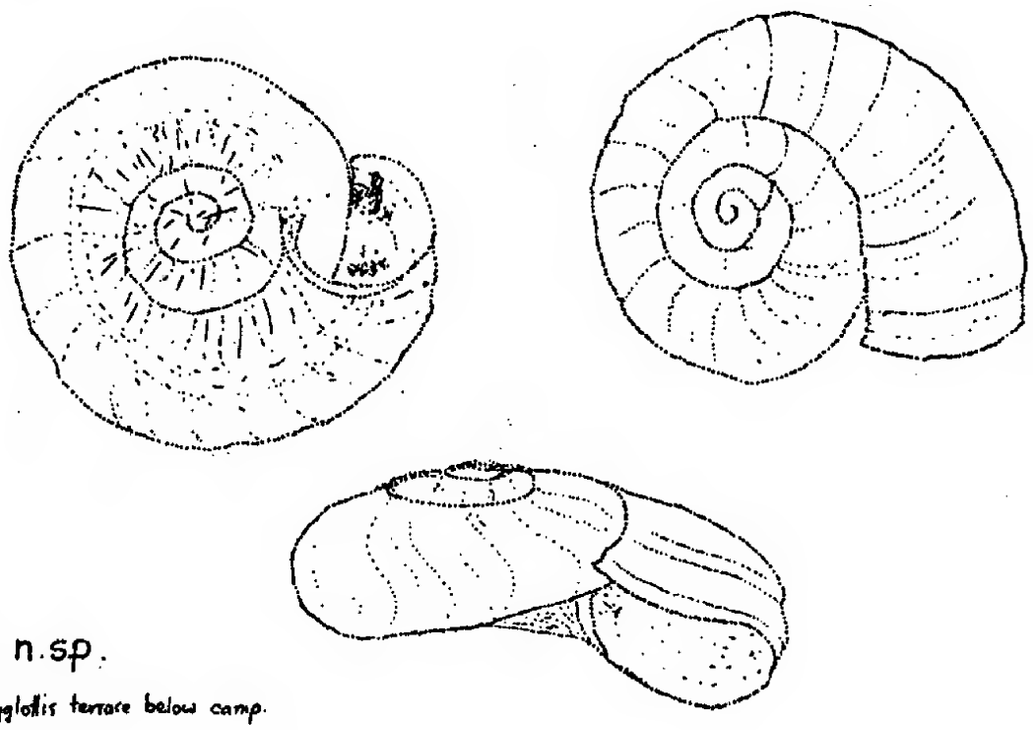
A form of D.coresia, the usual form on the North Cape block, has distinctive close, reddish colour banding radially, and a constant tendency towards a spiral band or bands on the outer edge of the shell especially, the spirals more obvious in some localities. Shells from Mt Camel appear to be the same but with the spiral banding obscure at best; shells from Hen Island and a juvenile from Cuvier Island appear to be of this type. All these shells have tighter coiling than D.coresia, a different surface microsculpture, and evidently should be named as a new species, the North Cape and Northeast Northland representative of the D.coresia type of shell (as distinct from the Three Kings type).

An apparent good species is also found in Kaeri Bush at the rest area by the bridge at the Southern end of the Waipoua forest. It has been named "coresia" in the past, being the same size and general shape, but seems abundantly different, All shells from several dozen we have examined are yellow-straw in colour and show not the slightest trace of either spiral or radial colour bands. The periostracum is glossy, spiral grooves being almost non-esistent. Where present, the spiral grooves are pointing in a strictly spiral direction, whereas the numerous clear grooves on a coresia shell (when fresh) tend to splay out and over the periphery of the shell. The best shell of a lot of 30 is illustrated.

Pale coresia-type shells with a greenish tinge have been found in Grafton Gully, Auckland (reported in Poirieria) and Motu (East Cape) and localities north of Auckland; these seem to be just colour forms.

We feel there are two distinct species groups in New Zealand Delos. In the first group, D.regia, D.striata and Bruce's arbutus "jeffreysiana"have wide, hollowed-out umbilical cavities in which the whorl surface is nearly or actually concave, and all these shells have prominent axial folds (most marked in striata). In the second group, the umbilicus is smaller and does not develop the angled shoulder at the top of the umbilicus (typical of the first group); axial folds are less regular and not so prominent; compared to the first group, which is restricted to the Three Kings, this second group ranges from the Three Kings down to the top of the South Island.

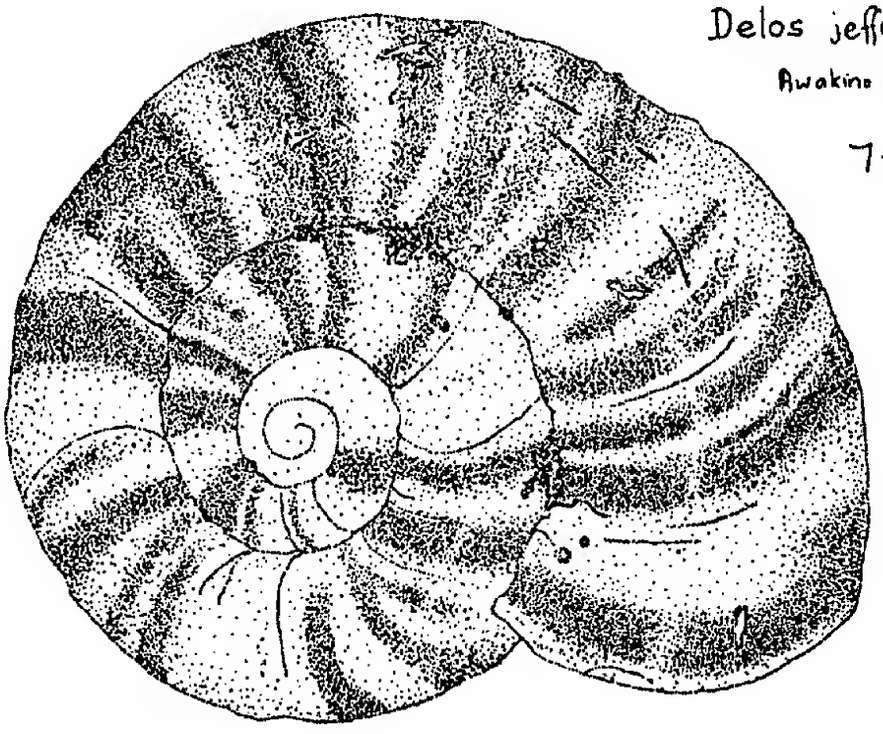
The figures by the illustrations give the size of each actual shell, as the major diameter in millimetres.



Delos n.sp.

Top edge of Brachyglottis terrace below camp.
Great Island, Three Kings group.

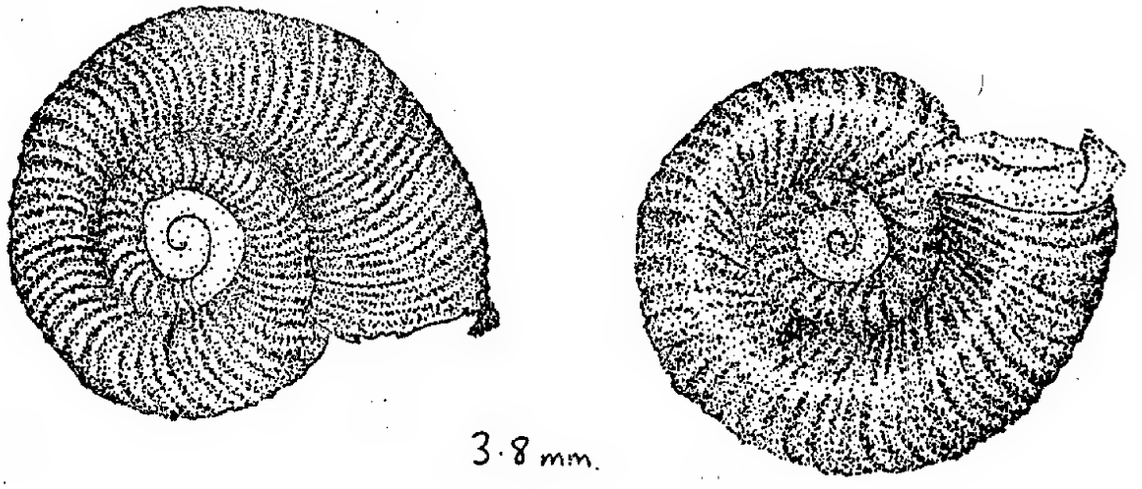
(Ouagapia n.sp.)



Delos jeffreysiana

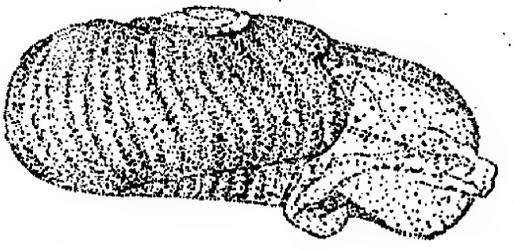
Awakino Gorge.

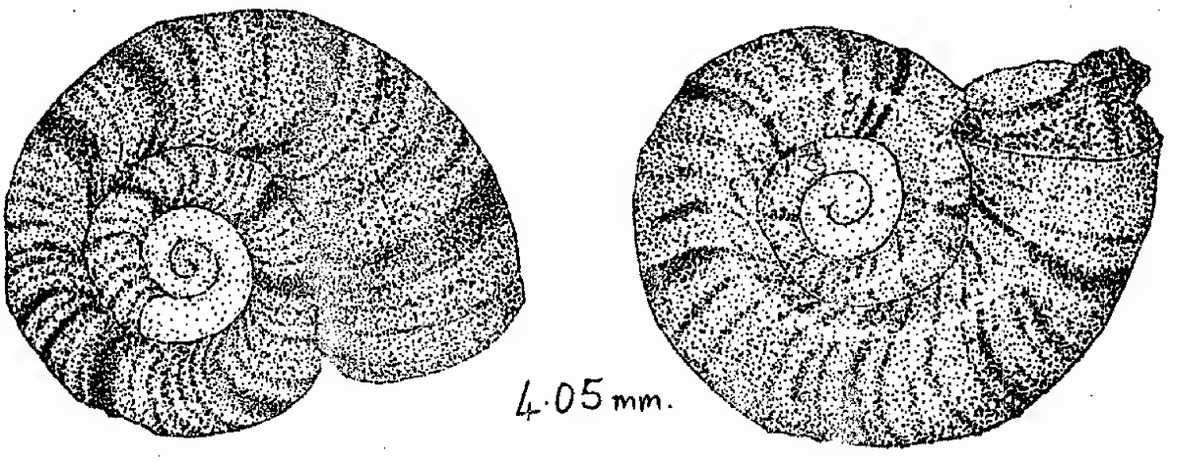
7·0 mm.



3·8 mm.

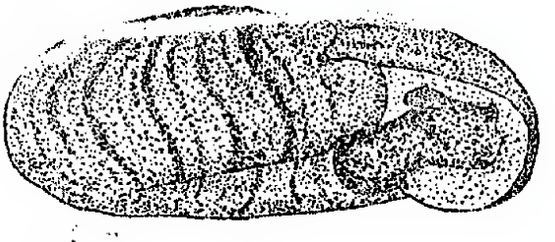
Delos striata
paratype.
(Ouagapia striata)

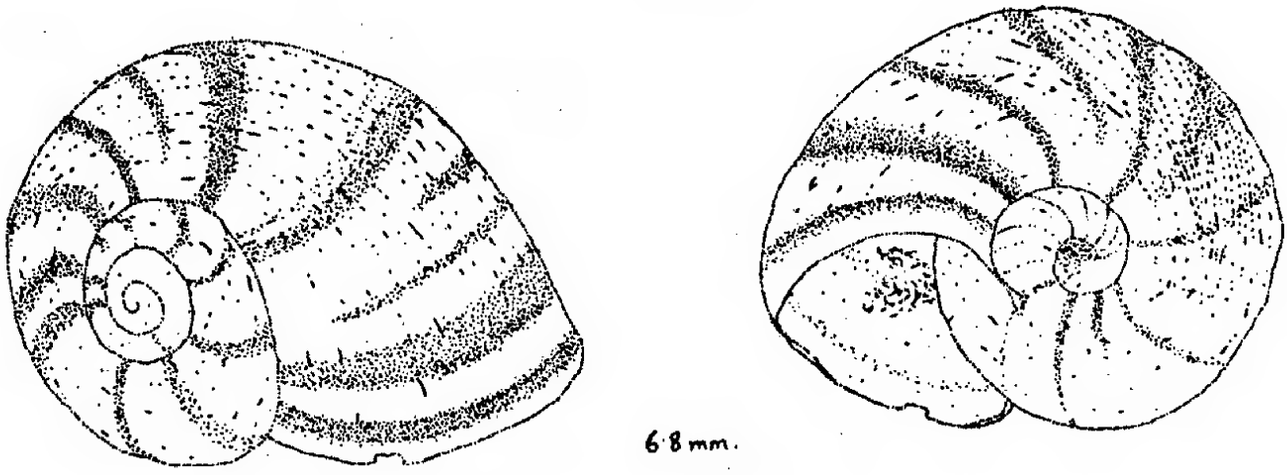




4·05 mm.

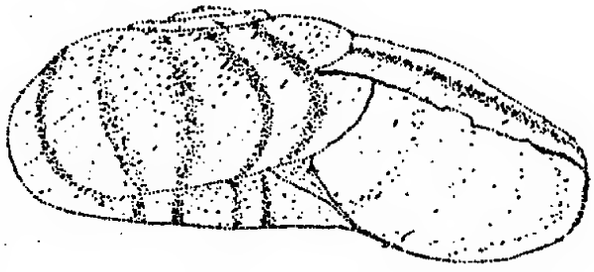
Delos regia
paratype.
(Ouagapia regia)

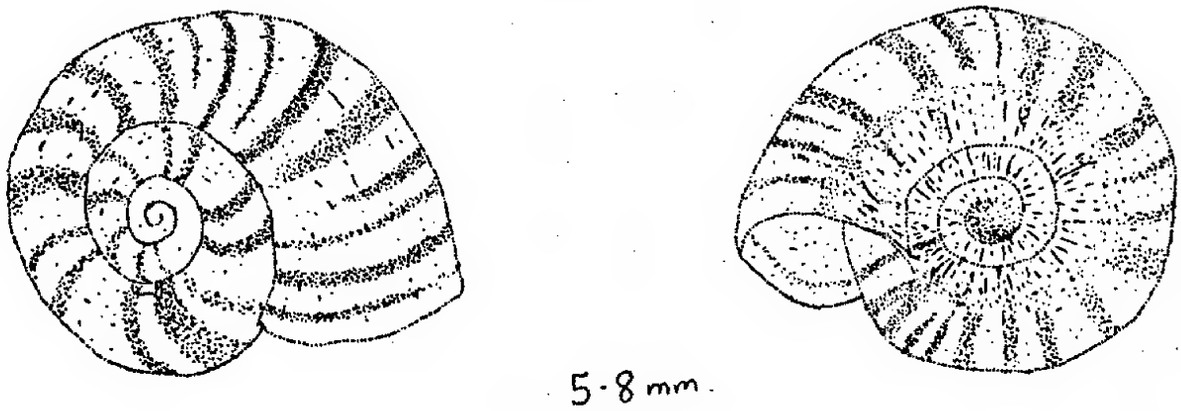




6·8 mm.

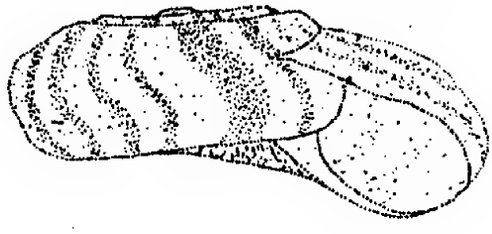
Delos n.sp.
("giant coresia")
Placostylus b bollonsi colony,
Great King Island, Three Kings.

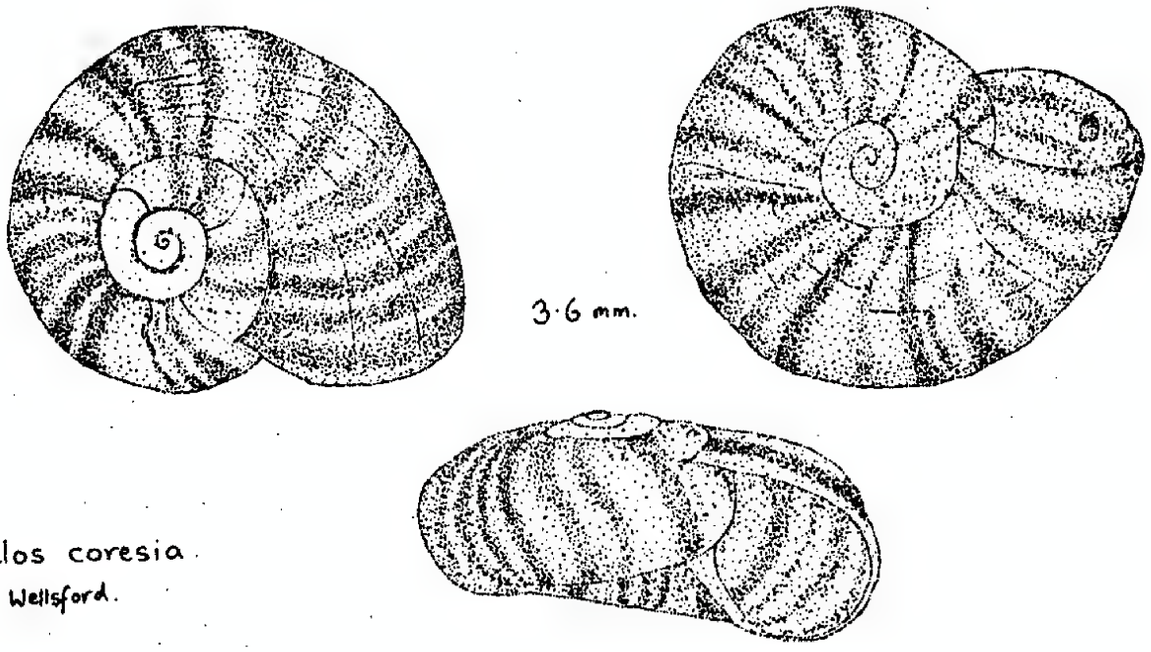




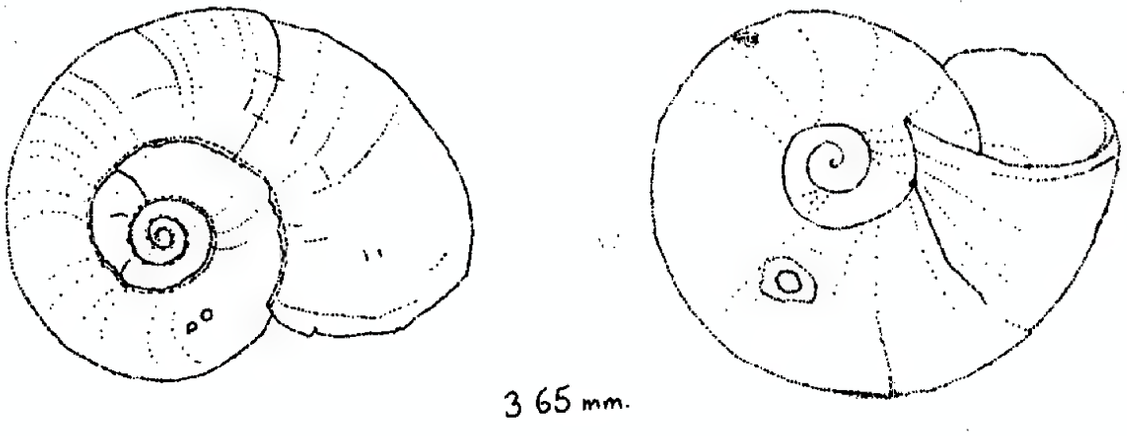
5·8 mm.

Delos n.sp.
("wide umbilicus")
(Ouagapia n.sp.)
Placostylus b. arbutus colony.
Great King Island, Three Kings.

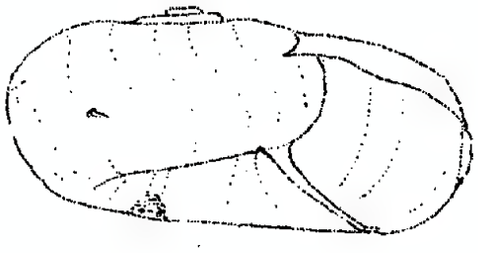




Delos coresia
Wellsford.

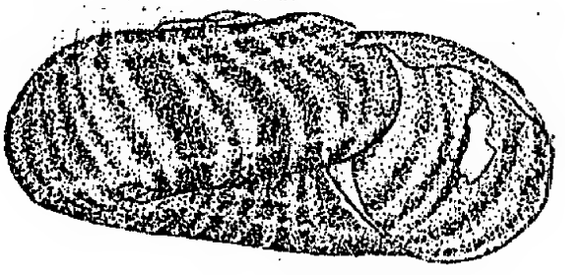


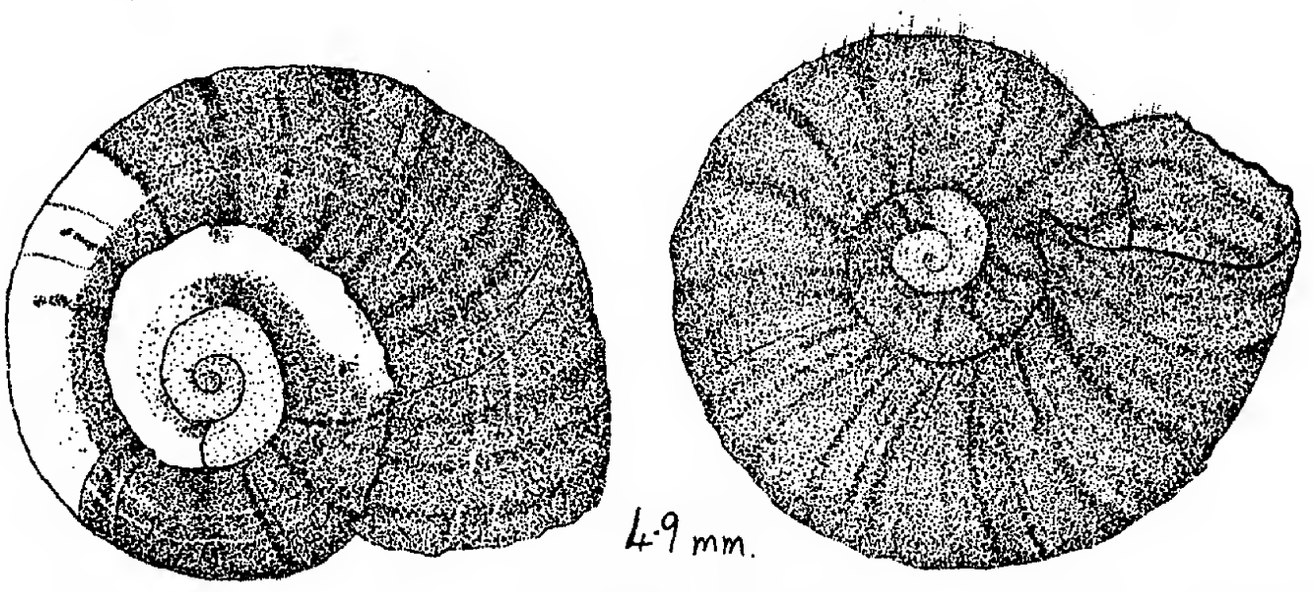
Delos sp.
Waipoua forest.



4·25 mm.

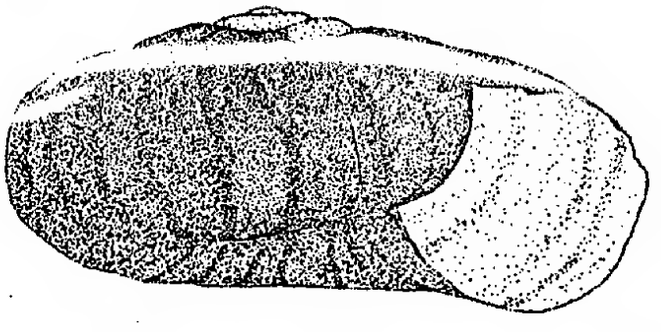
Delos n.sp.
Taputaputa Bay.

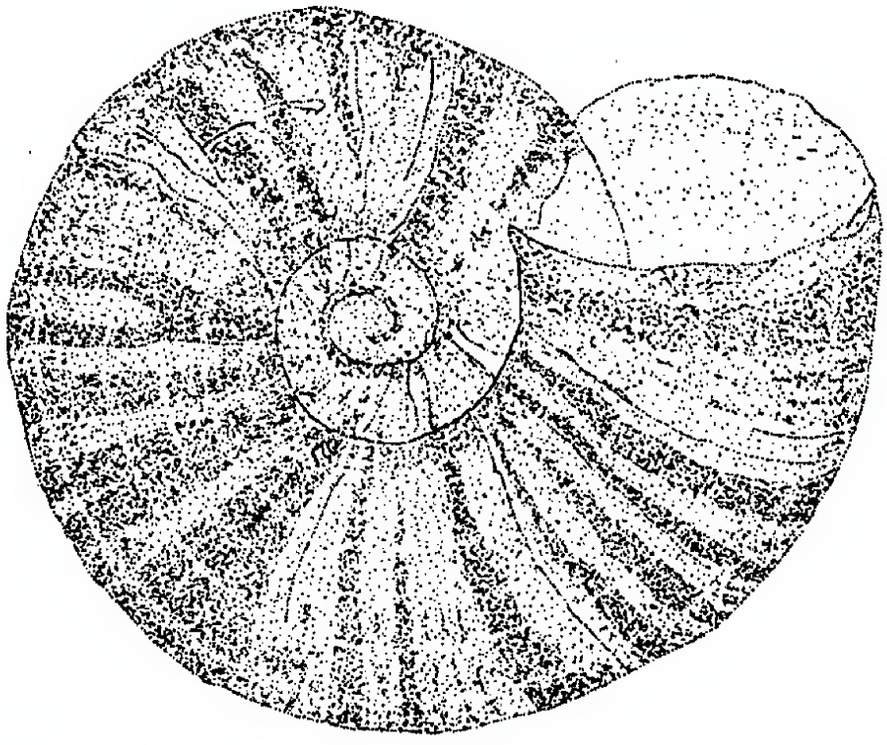




4·9 mm.

Delos n.sp.
Houhora: Mt. Camel.

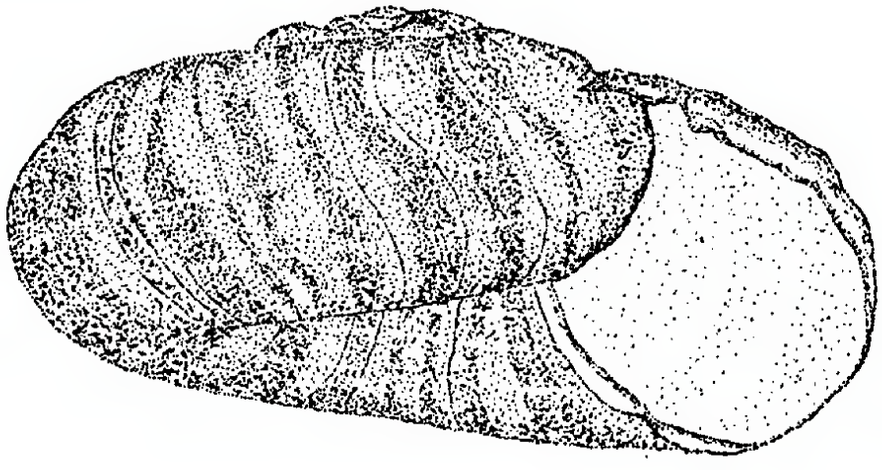




Delos jeffreysiana

Awakino Gorge.

7.0 mm.



B. F. H.

THE LARGER NEW ZEALAND FOSSIL AND LIVING TURBINIDAE

A. G. Beu

This summary is concerned with relationships of the larger Turbinidae (Subfamily Turbininae) with a flattened, carinate apex, and will not consider the minute species (Subfamily Homalopomatinae) lacking the flattened apex.

Important taxonomic criteria are the shell sculpture (smooth, granulose, or with peripheral spines), the sculpture of the calcareous operculum, or "cat's eye" (smooth, ridged, or with internal or external granules or nodules), and the radula.

Genus Turbo Linnaeus, 1758

Type species: T. petholatus Linnaeus, Indo-West Pacific.

The typical subgenus contains only the smooth, polished, brightly coloured type species, and a close Caribbean relative.

Subgenus Lunella Roding, 1798

Type species: Turbo cinereus Born, 1778, Indo-West Pacific.

Whorls lightly carinate, nodular to almost smooth; columella with basal lobe; operculum smooth to weakly granular.

Turbo (Lunella) smaragdus (Linnaeus, 1758)

A weakly sculptured species of Lunella with a smooth operculum. Abundant throughout New Zealand grazing on algae on rocky shores, reaching their largest size in the south. Not known as fossil.

Subgenus Modelia Gray, 1850

Type species: Turbo granosus Martyn, 1784, New Zealand.

Turbo (Modelia) granosus Martyn, 1784

The single species of Modelia has fine, even granules all over the pink to dark red shell, evenly rounded whorls, and a closely and finely evenly granulose, convex operculum. Known rarely as a fossil in Nukumaruan rocks near the Ruahine Range in Manawatu, and as a common Nukumaruan and Castlecliffian fossil in N. Canterbury. Living specimens are uncommon in southern New Zealand and rare in the north.

Subgenus Sarmaturbo Powell, 1938

Type species: Turbo superbus Zittel, 1864, Miocene, New Zealand.

Large, low-spired, nodulose species closely resembling the living South African T. (Sarmaticus) sarmaticus Linnaeus, but with operculum having spiral ridges, rather than inner surface; found only in the Miocene of New Zealand (a synonym of sarmaticus?)

Turbo (Sarmaturbo) superbus Zittel

A huge (up to 5" - 6"), low, wide, strongly noduled species from lower Miocene localities at Kawau Island, Cape Rodney, Mataura River, and Castle Hill Basin.

Turbo (Sarmaturbo) colini (King)

A slightly smaller species with smaller and more numerous nodules found rarely at Hurupi Stream, eastern Palliser Bay (Upper Miocene).

Subgenus Marmarostoma Swainson, 1829

Type species: Turbo chrysostomus Linnaeus, 1758

Operculum smooth to granulose; shell with many closely spaced, strongly granulose spiral ribs. The abundant tropical Pacific turbinid today, represented in New Zealand by unnamed lower Miocene forms from Hokianga and Castle Hill Basin.

Genus Cookia Lesson, 1832

Type species: Turbo sulcatus Gmelin, 1791 New Zealand.

A genus with two large, very scaly species with low peripheral spines and an operculum with two large, smooth spiral ribs. The radula differs from those of Turbo and Astraea quite markedly and shows that Cookia is related to the South African-Japanese genus Pomaulax and to the many American genera of Turbinidae.

Cookia sulcata (Gmelin, 1791)

The abundant, well-known "cook(s turban shell" found grazing large algae at and below low tide on rocky shores throughout New Zealand. Known as a rare fossil from Nukumarman rocks near the Ruahine Range in Manawatu only.

Cookia kawauensis Powell, 1938

Poorly preserved specimens similar in shape to C.sulcata but lacking the prominent, scalylam ellae; from Kawau Island, Auckland, and the Cookson Volcanics on the Kaikoura-Waiau road.

Genus Astraea Roding, 1798

Type species: Trochus imperialis Gmelin, 1791 = Trochus heliotropium Martyn, 1784, New Zealand.

This long-spined group is unique in the Turbinidae in being widely umbilicate. It evolved in New Zealand during the Eocene from Bolma, and is found ONLY in the Eocene - Recent of New Zealand and Eocene - Miocene of Australia; overseas (e.g. , American) species frequently referred to Astraea belong in other genera such as Astralium, Uvanilla, Lithopoma, Megastraea, etc.

Astraea heliotropium (Martyn, 1784

The well-known "star shell" or "circular saw", uncommon on beaches but dredged or trawled commonly in deeper water, especially abundant in Foveaux Strait.

Many Australian and New Zealand fossil species are known, differing from A.heliotropium in the width of the umbilicus, the strength of the scaly sculpture, and the presence or absence of a large ridge on the base (in A.bicarinata):

Astraea bicarinata Suter, 1917 (Lower Miocene, N.Z.)

hudsoniana (Johnston, 1888) (Lower Miocene, Aust.)
johnstoni (Pritchard, 1896) (Upper Eocene, Aust.)
stirps laws, 1932 (Lower Mid Miocene, N.Z.)

plus three unnamed N.Z. Eocene - Lower Miocene species,
plus one unnamed Australian Upper Miocene species.

(A. anthropophagus Warwick, N.Z., is inseparable from A. heliotropium, and A. stirps differs only in being slightly narrower and taller, with a slightly narrower umbilicus).

Genus Guildfordia Gray, 1850

Type species: Astralium triumphans Philippi; 1841, West Pacific from Australia to Japan.

A genus of granulose, polished species with a spiral cord defining the upper edges of the small to very long peripheral spines, with umbilicus filled with callus, and with a thin flat, smooth operculum.

Subgenus Guildfordia, sensu stricto.

Spines medium to very long; spire low; base with a shallow central hollow.

Guildfordia n. sp.

Close to G. triumphans, common at several Lower Miocene localities in Waitaki and Hakataramea valleys.

Guildfordia undosa (Chapman, 1912), upper Eocene, Victoria.

Subgenus Opella Finlay, 1927.

Type species: Astraea subfimbriata Suter, 1917, Lower Miocene, New Zealand.

Spines short; spire medium to tall; base flat. A subgenus found only in N.Z. with about four species of lower and middle Miocene age.

Subgenus Fractopella Beu, 1970

Type species: Fractopella megapex Beu, 1970

Like Opella, but with a large, rounded apex unlike that of other Turbininae. A single species; late Miocene of East Cape area.

Genus Bolma Risso, 1826

Type species: Turbo rugosus linnaeus, 1758, Mediterranean (= Incilaster Finlay, 1927, = Pseudastralium Schepman, 1908, etc. etc.).

A world-wide genus of about 100 species with a moderately tall spire, whorls usually angled at periphery and base, suture canaliculate on many species, base imperforate and usually with a widely spread (often orange) callus, and short to long peripheral spines.

Bolma recens (Dell, 1967)

- known from two tall-spired, short-spined, prominently angled, granulose specimens taken in deep water north of New Zealand.

B. marshalli (Thomson, 1908) and several other Eocene-Miocene N.Z. species are quite similar to B.recens. Also five Australian fossil and three or four Australian living species.

Genus Astralium Link, 1807

Type species: Turbo calcar Linnaeus, 1758, Recent, Indo-West Pacific.

The genus for the common, imperforate, short to long-spined, Indo-Pacific species of "Astraea". (= Bellastraea Iredale, 1924 = Pagocalcar Iredale, 1937, etc. etc.).
Subgenus Astralium sensu stricto
Astralium hokianga Laws, 1948

The few available small, low-spired, shells from Hokianga have spinose peripheries and closely resemble juvenile Australian Recent A. tentoriiformis, A. sirius, etc.

Subgenus Micrastraea Cotton, 193a

Type species: Trochus aureus Jonas, 1844, South Australia

A subgenus containing only two or three very small (½"), rounded species with oblique wavy ridges around the periphery. A single poorly preserved fragment from Opawa R., S. Canterbury (Oligocene) belongs in this subgenus.

Unusual Wash-up at Waikanae River Mouth

C.A.Fleming

On Dec 5, 1976 an unusual assemblage of molluscs was concentrated at high tide near the tip of the growing spit on the North side of the Waikanae River mouth. There were many variable Alcithoe arabica with colourful live animals, the usual Semicassis and a few Maurea selectum and Austrofusus with the common beach bivalves but the following which are usually less abundant on Waikanae Beach were also present:

Bassina yatei : about 15 fresh pairs, a few with animals
Maurea punctulata : 1
Maurea pelucida : 14
Maurea waikanae : 53
Astra heliotropium : 12
Alcithoe fusus : 6
Pelicaria vermis powelli Neef : 2
Argobuccinum tumidum : 1
Aeneator otagoensis cookianus : 2
Murexsul octogonus : 1
Poirieria zelandica : 1
Phenatoma novaezelandiae : 1

All the gastropods were dead but not badly worn. Some carried eggs of Alcithoe (both species), many had Zeacrypta in their apertures, and externally live or dead Balanus decorus, sponges and other epiphytic species including Gregoriella barbata, Musculus impactus, Monia zelandica (juv.) Ostrea lutaria (juv.) Waltonia inconspicua, and attached Foraminifera (Rosalina), polychaetes and Bryazoa. The starfish Astropecten was quite numerous.

Some of these shells (M.punctulata,Astra,Murexsul) represent a hard bottom high-energy environment probably in the tidal scour channel between Kapiti and the Golden Coast beaches where they are very rare indeed. Others (M.pellucida,M.waikanae, Pelicaria, Alcithoe fusus, Aeneator, Bassina) represent sandy habitats only occasionally represented by beach drift, probably at some considerable distance since none were still living. Finally the "normal" offshore fauna was represented by M.selectum (fewer than usual), Semicassis, and A. arabica, all of which included live specimens.

It is interesting to speculate on the special conditions that led to transport of shells about 4 km from a depth of 30-40 fathoms to the high tide mark at Waikanae. Possibly they started their journey in September, when storm waves from the north-west, with exceptional amplitude and eroding power, attacked the coast. Such waves may have brought the shells into shallower water where the normal waves were able to take over and shift them gradually onto the beach. None of the derived Castlecliffian fossils sometimes present at Waikanae were present.

COLLECTING NEW ZEALAND CENOZOIC FOSSIL SHELLS

A. G. Beu

New Zealand offers a uniquely complete sequence of rich fossil beds of Middle Eocene (Bortonian) to early Pleistocene (Castlecliffian) age that can be visited by the keen collector interested to learn about the history of the present molluscan fauna of the region. The accompanying diagram shows the stages and other divisions of Cenozoic time recognised in New Zealand. About a third of the land area of New Zealand is underlain by relatively young and soft, fossiliferous rocks, and there are few areas that are not within a day's drive of a good fossil locality. About 3000 species of Cenozoic fossil molluscs are recorded from New Zealand; many remain unnamed in collections, and many more are discovered each year by amateur and professional collectors alike, so that the field is a large one to which the careful amateur collector can make a major contribution.

Because the different fossil assemblages at different localities, or in many cases in different beds at one locality, can be used to both tell the ages of the rocks the fossils came from and determine the ecological conditions in which the fossils lived, it would be unfortunate if fossils from different localities or beds were muddled, so it is even more crucial to record accurate localities for fossil collections than it is for living shells. The best way is to record a geographic description of the locality, together with the grid reference on the relevant sheet of the New Zealand Map series 1 1" = 1 mile topographic maps, on each lot of specimens you get from each locality, together with the date and the collector's name(s) (see previous issue of COOKIA for information on both the traditional and the new metric grid references, and other data to record with fossil and present-day shells). Fossils are best labelled and sorted in individual species lots and incorporated in your collection in systematic order along with the present-day shells.

The named species of New Zealand Cenozoic fossil molluscs were listed by FLEMING (1966), along with a detailed bibliography, and a most useful collection of all the drawings of New Zealand fossil shells made by Dr Jack MARWICK.

Collecting Techniques

At most New Zealand Cenozoic fossil localities where the matrix is a soft to moderately hard siltstone or sandstone, fossils can be chopped out of the rock easily with a pointed geological hammer (Estwing, with steel shaft and nylon handle, is the best make; the sharper the better) once you've had a little experience at it. However, special techniques are needed at some localities.

Where the shells are at all soft or chalky, so that they can't be removed with a hammer without damage, the most useful technique is to cut around the specimen, a few centimetres away from it all around, with a sharp, stiff-bladed knife, to form a deep groove in the rock all around the fossil. The small slab so formed can then be levered off 'gently' and the fossil wrapped, and cleaned later at home. For large specimens in the same condition and, indeed, for most large fossils, a better technique is to chop a deep groove around them with the pointed geological hammer, and then lever or chisel the block off. Specimens in hard limestone or in

sandstone concretions can be removed safely (if slowly) by cutting around them with a large, narrow-pointed, steel-cutting cold chisel and a short, heavy hammer.

Separation of numerous and especially small fossils from a softish matrix can be done easily by the standard micropaleontology technique of soaking the dried rock in water until it breaks down to soft mud, and then washing the slurry through a very fine sieve. The shells remain in the sieve to be dried and sorted under a lens or microscope as you would shell-sand. Many special washing techniques can be used for breaking down unusually tough or hard rock; probably the most useful is concentrated hydrogen peroxide which, when added in small amounts to rock + water, will break down almost all rocks rapidly. Some people make a regular practice of separating shells from the resulting dried washing by floating the shells off in carbon tetrachloride (dry shells carefully in open air before sorting them!) but probably most people won't process enough samples for this to be necessary.

Cleaning Fossils

Most fossils can simply be washed under running water with a soft toothbrush, when shells from softish siltstone or sandstone such as at Castlecliff, Devil's Elbow, Clifden, Bluecliffs, etc., quickly look as clean as present-day shells. Specimens that were fragile enough to need removing in their individual blocks need to be picked out of rock carefully by digging the matrix away patiently with a needle; most useful is one mounted in a wooden handle (a cheap dissecting probe) or an old dental tool. Soft, fragile or cracked specimens need to be hardened with a solution that penetrates the shell deeply, such as "Octopus" glue dissolved in acetone, or (the best of several recipes we have tried at Geological Survey) uncoloured "Duco" automobile lacquer thinned well with "Duco" thinners. These mixtures can be painted on with a small watercolour brush (wash the brush in thinners) and will make your fossil quite strong again.

Fossils in hard limestone or in concretions can be removed by patient chipping with a hammer and a small, narrow-pointed cold chisel, resting the fossil on a felt pad or piece of softboard so the back surface isn't damaged. For more accurate and careful work with finely sculptured fossils at Geological Survey, we use a finely pointed, small, hand-held percussion drill called a "Vibrotool". Even more effective is a small, pen-sized, "air-scribe", a percussion drill powered by a cylinder of compressed air, but probably not many collectors will purchase these larger pieces of equipment.

Some Important Localities

The New Zealand Geological Survey has collections from about 5000 distinct localities in New Zealand Cenozoic rocks and it is clearly impossible to mention more than a few of these here. A number of localities are well known for their abundant fossils, and the richest of these are listed below :

Wangaloan (Paleocene) : Mitchells Point, Wangaloa, south of the mouth of Tokomairiro River, Otago, offers one of the world's few rich faunas of

earliest Tertiary fossils. Large boulders on the beach are crammed with specimens, but the rock is extremely hard, and good specimens are hard to find now.

Bortonian (Middle Eocene) : Hampden Beach, North Otago - the low cliffs behind the beach near the mouth of stream, 3-4 miles north of Hampden, have abundant chalky Eocene fossils which must all be treated with "Duco" as they crumble if left exposed to air.

Waihao Downs, South Canterbury - glauconitic sandstone ("greensand") in the abandoned railway cutting west of Waihao Downs, and cliffs of Waihao River ½-mile downstream, have common, excellently preserved, large molluscs.

Pareora Gorge, Canterbury - greensand in the bed of the Pareora River at the lower end of Pareora Gorge is richly fossiliferous, but exposed only when the river is unusually low in a long, dry summer.

Other localities are at Pahi, Kaipara Harbour; the lowest beds at McCullough's Bridge and in Westland.

Kaiaton (upper Eocene) : McCullough's Bridge, South Canterbury - greensand on Waihao River near Waihao Downs (bridge is signposted on main road) contains a very large fauna, but fossils are soft and must be collected very carefully.

Lorne - the site of the former Lorne Railway Station, Waiareka Valley, inland from Oamaru, has a hard, bright green turf, rich in hard-bottom molluscs; a unique fauna, but not for the inexperienced collector.

Duntroonian (Oligocene) : Head of Lake Waitaki - Wharekuri Greensand in low cliffs just east of Aviemore Dam is richly fossiliferous, and fossils can be cut out easily.

Chatton, north of Gore, Southland - brown-weathered greensand in a hillside outcrop above Okapua Creek, 2 miles north of Chatton, has the well-known "Shell gully" fauna, the richest Duntroonian one in New Zealand.

Duntroonian fossils are common in limestone and greensand at Castle Hill Basin, Hakataramea Valley, and a large number of other South Island localities.

Waitakian (late Oligocene and earliest Miocene) : Trig. Z, Waitaki Valley- the topmost beds in the low hill at Trig. Z contain abundant, varied, chalky fossils.

Brydone, Southland - a bed of fossils in the low cliffs of Mataura River east of Brydone is a most unusual association of shallow-water molluscs.

Waiheke Island, Auckland - richly fossiliferous shallow-water sandstone at Church (= Squadron) Bay and Little Oneroa Bay is well-known, thanks to the careful collecting of Dr POWELL, but fossils are difficult to collect.

Otaian (Lower Miocene) : Pareora River and (especially) Bluecliffs, Otaio River, Canterbury - soft blue-grey siltstone in these nearby Rivers contains many beautifully preserved shells, easily collected.

Pakaurangi Point, Kaipara Harbour (in part Altonian) - low cliffs east of Tinopai, provide a most unusual warm-water assemblage, especially for people interested in micromolluscs.

Altonian (Lower Miocene) : Clifden, western Southland - the most richly fossiliferous section in New Zealand is seen in the cliffs in the south banks of Waiau River upstream from Clifden Bridge, north of Tuatapere (see also Clifdenian, Lillburnian, Waiauan). The best Altonian fossils are in Fouraye Siltstone, Calamity Point Sandstone and Long Beach Shellbed.

Rifle Butts Formation, Oamaru - the famous localities at Target Gully, Awamoa Creek and old rifle butts, Awamoa Beach, all close to, or within Oamaru, are richly fossiliferous. Target Gully is now a scientific reserve, and special permission is needed to collect there.

North shore of Parengarenga Harbour - richly fossiliferous shellbeds and long siltstone outcrops across from Te Hapua contain a large number of new species of warm-water molluscs, but access is very difficult.

Clifdenian, Lillburnian, Waiauan (middle Miocene) : All most fossiliferous at Clifden, Southland, in beds above Long Beach Shellbed (see under Altonian). Other rich localities in Westland, and, (for Waiauan) : Lower Waipara Gorge and Weka Pass, Canterbury.

Tongaporutuan (upper Miocene) : Hurupi Stream, Palliser Bay - much the richest Tongaporutuan locality in New Zealand, fossils easily collected, and an easy day trip from Wellington.

Many other localities in Taranaki, southern Wairarapa, Westland, Marlborough, North Canterbury.

Kapitean (latest Miocene) : Te Araroa, East Cape - the long cliffs between Te Araroa and East Cape are richly fossiliferous at several localities, especially in the wide, wave-cut platforms.

Many other localities near Hokitika, Te Waewae Bay in Southland, Awatere River, Marlborough, and the Chatham Islands.

Opoitian (early Pliocene) : Kaawa Creek, coast south of Waikato Heads - a very rich fauna of shallow-water molluscs in blocks, fallen from high up a cliff face. Access is difficult.

Cape Kidnappers - sandstone between Black Reef and the shelter huts, exposed only at low tide, contains abundant fossils.

Awatere River, Marlborough - fossils are abundant in a huge rockfall south of the mouth of Upton Brook.

Many less richly fossiliferous localities in Westland (Lower Kaniere Rd.) and in Wairoa area, Hawkes Bay.

Waipipian (Late Pliocene) : Waverley Beach, west of Wanganui - the Waipipi Shellbeds at Waverley Beach, crammed with huge bivalves, provide perhaps the most spectacular fossil locality in New Zealand.

Waihi Beach, Hawera - scattered, excellently preserved shells in grey sandstone.

Other good localities are Te Reinga Falls, inland from Wairoa; Te Mata Peak, Havelock North; Lower Waipara Gorge; Awatere River (near road bridge) and Starborough Creek, Seddon; and in Westland.

Mangapanian (late Pliocene) : The best locality is Wilkies Shellbed, Wilkies Bluff, east of mouth of Waitotara River, but access is very difficult.

Abundant fossils also in Waitotara Valley (Mangapani Shellbed), Te Aute Limestone of Hawkes Bay, Waihua River, Wairoa, and many southern Wairarapa and North Canterbury localities.

Nukumaruan (latest Pliocene and early Pleistocene) : Nukumaru Beach, west of Wanganui - soft brown sand, richly fossiliferous; access is by road south of Waitotara, past lime quarries in "Waitotara desert" and along beach from fishing rock.

Petane siltstone, Hawkes Bay - the best-preserved inner shelf gastropod faunas of Nukumaruan age are in Hawkes Bay (Devil's Elbow hill, Ashcott Road, Maharakeke Road, Okauawa Stream, Mangatahi River) in soft siltstone and sandstone.

Southern Wairarapa - fossils are abundant in many stream and coastal sections at Castlepoint and from Gladstone to southeast of Martinborough, especially in Mangaopari Stream, Makara River, Ruakokopatuna River area.

Castlecliffian (late lower Pleistocene) : The long, continuous section from Castlecliff to several miles west of Kai Iwi, Wanganui, is probably the most complete and most richly fossiliferous Pleistocene section in the world. Most fossils are species still living, and all are beautifully preserved and easily collected. Keep collections from different beds separate PLEASE!

Te Piki, Cape Runaway - the only other richly fossiliferous Castlecliffian locality is in the road cutting 4 miles east of Cape Runaway, on the main road to Hick's Bay. The large number of fossils is perfectly preserved and retains much of the original colour.

Late Pleistocene : Waihi Beach, Hawera - on your way down the track to the Waipipian fossils, collect from the thick, crammed shellbed (mostly worn, shallow-water shells) at the base of the Hawera series beds forming the upper half of the cliff; much the best bed this young in New Zealand.

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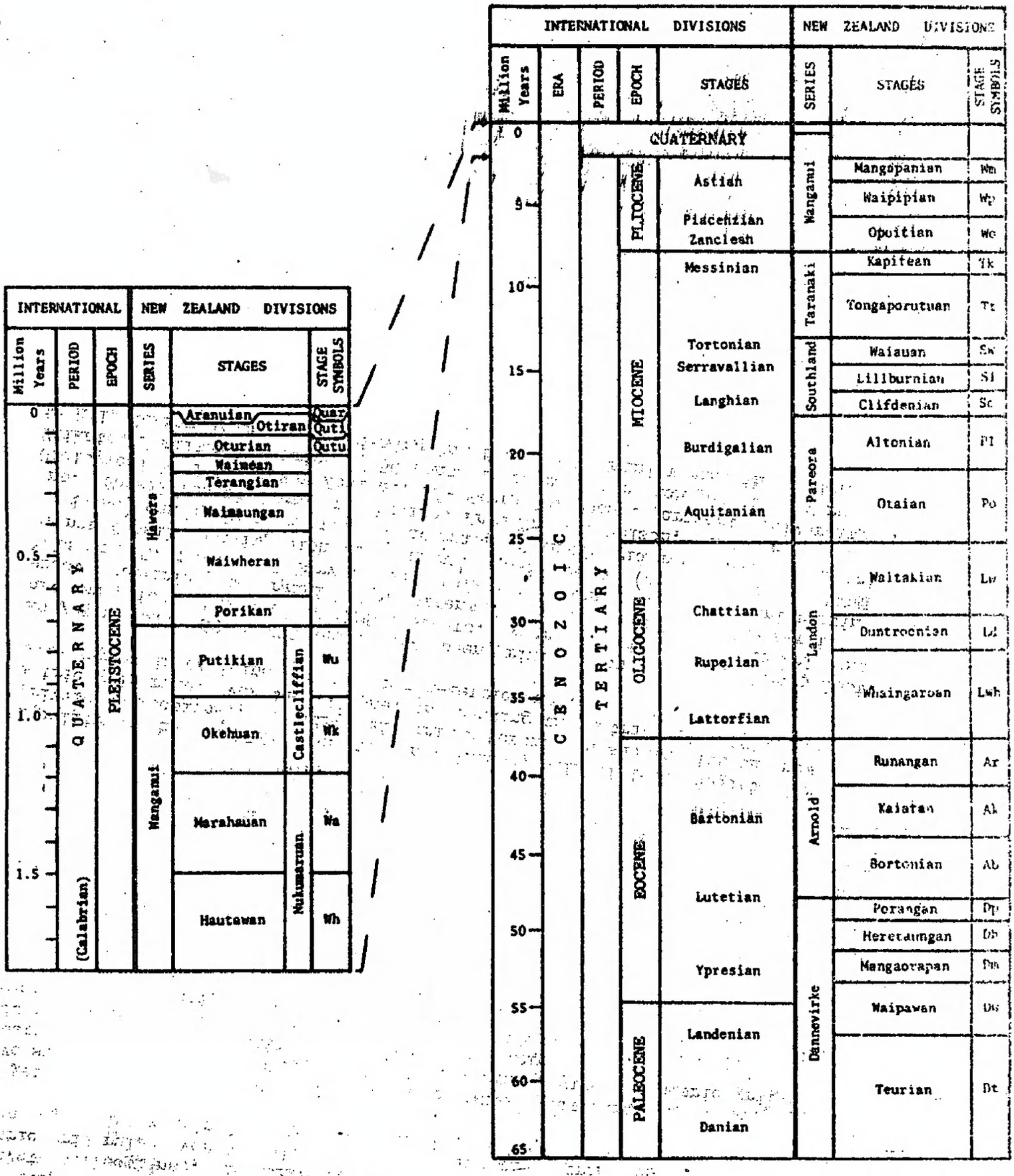
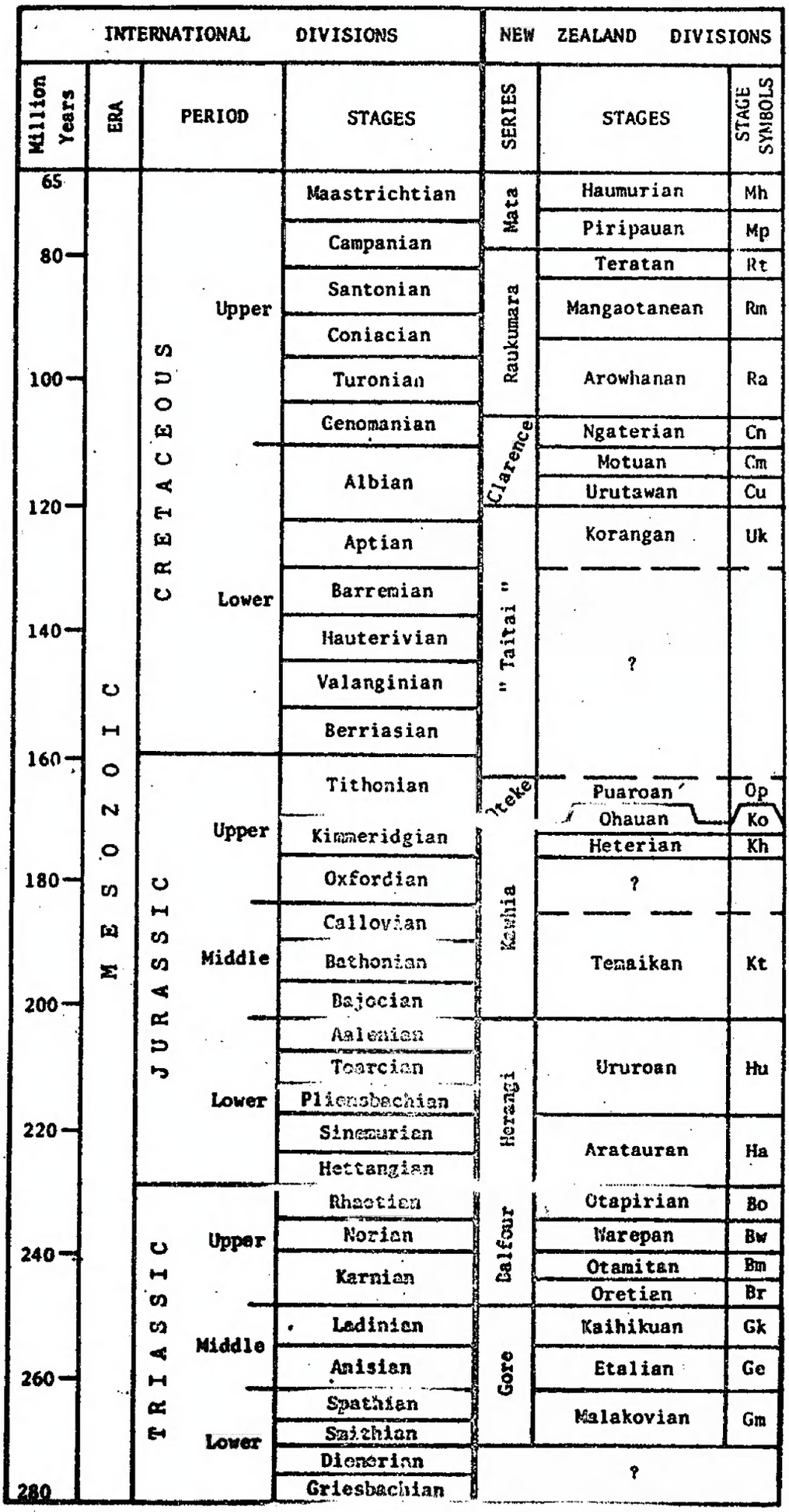
Age, m.yrs. before present	Era	Period	EPOCH	N.Z. Series	New Zealand Stages
0	CENOZOIC	Quaternary	PLEISTOCENE	Hawera	
1·5?				Wanganui	Castlecliffian Nukumaruan Mangapanian Waipipian Opoitian
		TERTIARY	PLIOCENE		
5			MIOCENE	Taranaki	Kapitean Tongaporutuan
				Southland	Waiauan Lillburnian Clifdenian
				Pareora	Altonian Otaian
22·5			OLIGOCENE	Landon	Waitakian Duntroonian Whaingaroan
37·5			EOCENE	Arnold	Runangan Kaiatan Bortonian
				Dannevirke	Porangan Heretaungan Mangaorapan Waipawan
53·5			PALEOCENE	(Wangaloan?)	Teurian
65					

NEW ZEALAND GEOLOGICAL TIME SCALE WITH EQUIVALENT INTERNATIONAL UNITS — CENOZOIC



NEW ZEALAND GEOLOGICAL TIME SCALE WITH EQUIVALENT INTERNATIONAL UNITS — MESOZOIC



NEW ZEALAND GEOLOGICAL TIME SCALE WITH EQUIVALENT INTERNATIONAL UNITS — PALEOZOIC